CALIFORNIA'S SUSTAINABLE GROUNDWATER MANAGEMENT ACT OF 2014:

Recommendations for Preventing and Resolving Groundwater Conflicts

WATER IN THE WEST

Stanford Law School
Martin Daniel Gould Center for Conflict Resolution Programs

April 2015

Authors

Tara Moran, Program Lead, Sustainable Groundwater, Water in the West

Amanda Cravens, Gould Fellow, Martin Gould Center for Dispute Resolution

Acknowledgments

The authors would like to thank all of the Groundwater Dispute Resolution workshop participants. The report was significantly improved by feedback provided by Leon Szeptycki, Janet Martinez, Janny Choy, Gina Bartlett, Anna West, Marcelle Else DuPraw, as well as several anonymous reviewers.

Contact

Water in the West
Stanford University
Jerry Yang and Akiko Yamazaki (Y2E2) Building
473 Via Ortega, MC 4205
Stanford, CA 94305
waterinthewest@stanford.edu

About Water in the West

Water in the West is a partnership of the faculty, staff and students of the Stanford Woods Institute for the Environment and the Bill Lane Center for the American West. The mission of Water in the West is to design, articulate, and advance sustainable water management for the people and environment of the American West. Linking ideas to action, we accomplish our mission by engaging in cutting-edge research, creative problem solving, active collaboration with decision-makers and opinion leaders, effective public communications and hands-on education of students. To learn more visit: waterinthewest.stanford.edu.

Photo taken by Chris Austin

ABOUT THE AUTHORS

Tara Moran, Program Lead for Water in the West's Sustainable Groundwater program. Tara combines her passion for science with strong communication skills and a strong desire for practical groundwater management solutions. She identifies research opportunities for improved groundwater management and connects groundwater managers throughout California and the western US with groundwater researchers at Stanford University. She also works with policy makers and other agencies to advance groundwater policy for sustainable groundwater management.

Amanda Cravens, as a Gould Fellow at Stanford Law School, Amanda is collaborating with Water in the West's Sustainable Groundwater program to use legal and social science research to help California achieve more sustainable groundwater management. Her current projects focus on lessons to be learned from past groundwater adjudications, ways to prevent and resolve groundwater disputes, the role that scientific information and technical models play in decision making processes, and the potential for interactive collaborative models to help diverse stakeholders work together.

TABLE OF CONTENTS

LIST OF BOXES

LIST OF FIGURES

LIST OF TABLES

EXECUTIVE SUMMARY

Prior to the passage of the Sustainable Groundwater Management Act of 2014 (SGMA), California lacked statewide regulation of groundwater pumping or standards for groundwater management. Unconstrained use of this resource has led to widespread lowering of water tables, land subsidence, and impacts to surface waters, groundwater-dependent ecosystems and water rights holders. Groundwater extractions are estimated to exceed natural recharge at a rate of approximately two million acre feet per year (DWR Water Plan 2013), resulting in declining groundwater levels in many groundwater basins throughout the state. The persistent declines in groundwater levels have led to many serious economic, social, and environmental impacts, and inevitably, disputes over how to allocate the increasingly limited resource. Given the new mandate for groundwater planning under SGMA, there is a major need to develop policy recommendations and dispute resolution tools that can help to achieve groundwater allocation decisions that are negotiated, equitable, sustainable, and supported by water users as well as other stakeholders. While SGMA attempts to address many of these challenges by developing a statewide framework for sustainable groundwater management, many questions remain about how the law will be implemented, the effect that it will have on resolving current and future groundwater conflicts, and whether the groundwater sustainability plans (GSPs) it mandates will be challenged through court adjudications.

To address this problem, Stanford University's Water in the West program and the Martin Daniel Gould Center for Conflict Resolution Program at the Stanford Law School convened a group of groundwater users, water managers, conflict resolution experts, water lawyers, and researchers to consider how the new groundwater legislation would change the landscape of groundwater conflicts and resolution in California. Held in November 2014, just two months after the passage of SGMA, the workshop explored common drivers in groundwater conflicts in California, barriers to resolving these conflicts, and possible solutions for moving forward.

This report summarizes the key findings from the workshop. A list of participants and research ideas generated is provided in Appendices A and B, respectively. Workshop participants identified six broad challenges or barriers to resolving groundwater conflicts and achieving sustainable groundwater management in California, including 1) fragmented groundwater management; 2) voluntary groundwater management; 3) legal uncertainty in SGMA; 4) property rights and existing legal rights to water; 5) inadequate information, models and data dissemination; and 6) funding and support. Some of these barriers have been addressed with the passage of SGMA; however, its successful implementation will require that the state develop effective policy tools and best management practices to guide agencies, stakeholders and interested parties through the process.

In order to address these broad challenges in resolving groundwater conflicts, key findings that could be undertaken in the next three years to streamline or support SGMA implementation include:

1. **State intervention -** The Department of Water Resources (DWR) and the State Water Resources Control Board (SWRCB) need to develop clear criteria and definitive action for how the state will intervene and enforce in groundwater basins not achieving sustainability goals.
2. **Groundwater property rights –** Groundwater property rights in California should be clarified, so they are predictable and transferable. Since SGMA does not change property rights, any GSP that is perceived to violate these rights will risk legal challenge. GSAs thus need to prioritize engagement of all interested parties. At the same time, the legislature or courts should consider means to make GSPs developed under SGMA legally binding.
3. **Facilitated support for SGMA implementation -** The state should provide a list of experienced groundwater facilitators and/or mediators who can help with SGMA implementation. State funding for facilitated support would help.
4. **Collaborative processes -** DWR and the SWRCB, in conjunction with research institutions and mediators, should develop best management practices for collaborative processes. Materials could include templates, courses and educational materials. Guidance and tools for evaluating the applicability of existing collaborative approaches for SGMA compliance and improving their usefulness for groundwater allocation decisions would also be very helpful.
5. **Funding -** The state should provide consistent, accessible funding for GSA formation and GSP development and implementation. These funds should be tied to specific and measureable goals and timelines.
6. **Case studies -** Research institutions, state agencies, and public policy centers should develop case studies from California, other states and other countries that can serve as examples of sustainable groundwater practices.

SGMA represents a significant step forward in addressing conflicts over groundwater in California and moving toward sustainable management. However, the success of the legislation ultimately depends on active participation, guidance and an ongoing commitment to the process from numerous entities, including state agencies, water lawyers, mediators, groundwater policy experts, local agencies, agricultural users, municipalities, social and environmental justice groups and others, to ensure that the local groundwater agencies have the tools, resources, and community support to manage groundwater resources effectively over the long-term.

Introduction

This report summarizes the key findings of a workshop on groundwater dispute resolution co-hosted by Stanford University's Water in the West program and the Martin Daniel Gould Center for Conflict Resolution Program on November 5-6, 2014. The report was prepared by Tara Moran, Program Lead for Water in the West's Sustainable Groundwater Program and Amanda Cravens, Gould Fellow at Stanford Law School's Martin Daniel Gould Center for Conflict Resolution. It contains the authors' analysis and synthesis of the workshop and does not reflect the individual views of any particular participant.

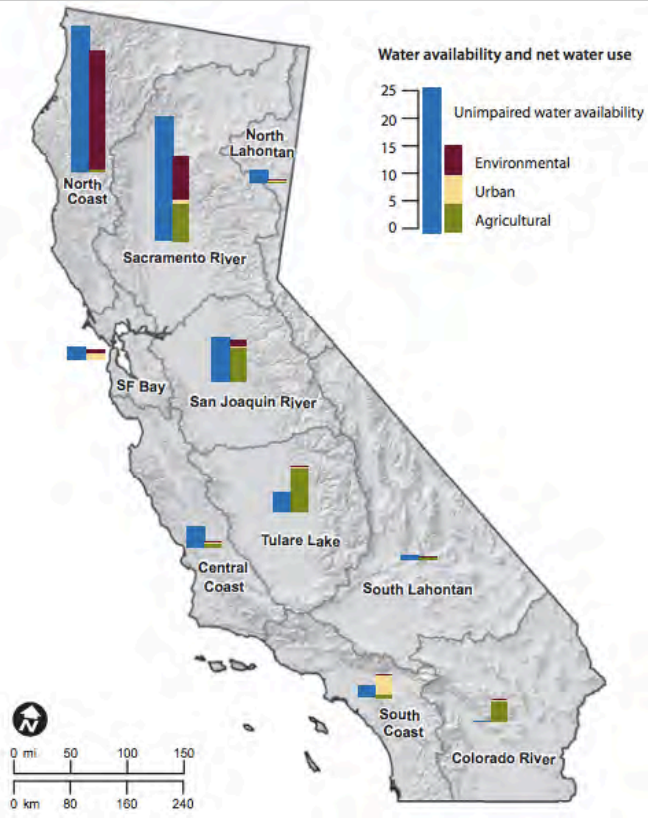
Workshop motivation and goals

Groundwater is a critical component in global health and food security, providing a clean, reliable drinking water source for more than two billion people worldwide (Morris et al. 2003), and an estimated 36 percent and 42 percent of the world's domestic and agricultural freshwater use, respectively (Doll et al. 2012).

In California, groundwater supplies between one-third and two-thirds of the state's freshwater supply annually, depending on climatic conditions (see Box 1). A growing population and a booming economy have taxed the state's surface water supply, making groundwater an increasingly valuable water source—particularly during drought years when surface water supplies are limited. The California Department of Water Resources (DWR) currently estimates that groundwater extractions exceed natural recharge at a rate of approximately two million acre feet per year (DWR Water Plan 2013). Unregulated extractions in many basins have caused persistent decline in groundwater levels, leading to serious economic, social, and environmental impacts and in many cases conflicts over the resource.

Box 1. Water in California - Facts and Figures

- California receives an average of 200 million acre-feet (maf) of precipitation each year (Water Plan, 2013, 3-33). (An acre-foot of water is 325,850 gallons, enough to supply two to four families with enough water for a year.)
- Just over 70 maf of the precipitation received flows to rivers and streams or infiltrates into groundwater aquifers where it can be used; the remaining 130 maf is lost through evaporation and transpiration from plants.
- Water availability and use across the state varies immensely, both in the amount of water used and the sectors that use it. Net water use in Southern California far exceeds water availability (see Figure 1).
- Between 1920 and 1960, Southern California water districts focused on increasing imported water supply. However, as imported water sources became increasingly difficult to find and expensive to procure, groundwater adjudications[1] became more common.



- California's first groundwater adjudication, the Raymond Basin Adjudication, was filed in 1937.
- Between 1998 and 2005, groundwater accounted for an average of 15 maf/year or approximately 25 percent of the state's agricultural and urban water use. Owing to recent droughts, this number has increased in recent years to nearly 40 percent of the state's total water supply.
- The California Department of Water Resources estimates that statewide overdraft of groundwater may be as high as 2 maf/year, with 1.4 maf/year of that occurring from agricultural use in the Tulare Basin.
- Agricultural use accounts for approximately 80% of all groundwater used in the state (Nelson 2012).

Figure 1. Water availability and net water use by sector in California's ten hydrologic regions (Hanak et al. 2011).

Groundwater overdraft[1] often leads to conflicts between groundwater users seeking to protect their groundwater rights. While the actual number of conflicts between groundwater users is difficult to determine due to the number and diversity of agencies involved in groundwater management, a study by Nelson (2014) documented 55 groundwater-surface water conflicts across the state between 2008-2012. This study demonstrated that the majority of these conflicts resulted from reduced surface water flows and impacts to groundwater-dependent flora and fauna caused by the lowering of groundwater levels through groundwater pumping. The study represented a diverse community of disputants, including local and national nongovernmental organizations, and surface water-dependent water utilities.

Long-term trends in groundwater depletion have been exacerbated by recent drought conditions. The exceptionally warm and dry conditions California has experienced

[1] Groundwater overdraft is the chronic lowering of groundwater levels over a period of years that never fully recover, even in wet years.

since 2012 (Swain et al. 2014; Griffin and Anchukaitis 2014; Diffenbaugh et al. 2015) have led to surface water shortages and increased reliance on groundwater. A Drought Response report issued by DWR in 2014 reported all-time historical lows for groundwater levels in most areas of the state (DWR 2014a). The warm temperatures and lack of precipitation that produced the present drought are expected to become increasingly common with climate change; in the coming decades, the majority of dry years will more likely occur with warm temperatures (Diffenbaugh et al. 2015). The resulting uncertainties in surface water deliveries due to a diminishing snowpack and changing regulatory environment are all likely to exacerbate many of the challenges Californians are currently facing in achieving sustainable groundwater management moving forward. It will thus become increasingly important that water managers work collectively to manage this resource effectively and for the benefit of all stakeholders. Adaptive management[2] and conjunctive water management[3] will become important tools for successful water management in this future climatic regime (Pahl-Wostl 2007; Engel et al. 2011). In 2011, the Environmental Protection Agency and DWR, in conjunction with Resources Legacy Fund and the U.S. Army Corps of Engineers, developed the *Climate Change Handbook for Regional Water Planning*, which provides a framework for incorporating climate change into regional water planning efforts.

Prior to the passage of the Sustainable Groundwater Management Act (SGMA) in 2014, adjudicating the water rights of all groundwater users in a basin through the courts was the only way for groundwater users to stop or reverse groundwater overdraft (absent agreement). While adjudication can provide legal certainty and clarity, the process is typically time consuming, expensive, unpredictable, and largely driven by the narrow goal of attaining "safe yield"[4] for a groundwater basin. Additionally, as pointed out by Enion (2013), California's complex system of priority water rights has resulted in groundwater adjudications that do not necessarily result in clearly defined individual property rights and often favor the status quo by protecting the interests of large water users over smaller pumpers.

When considering the burdens and costs of the adjudication process alongside the new mandate for groundwater planning under SGMA, there is clearly a need for policies and dispute resolution tools that can help to achieve groundwater allocation decisions that are negotiated, equitable, sustainable, and supported by water users as well as other stakeholders. While SGMA attempts to address many of these challenges by developing a statewide framework for sustainable groundwater management, many

[2] Adaptive management is an approach to resource management that "promotes flexible decision making that can be adjusted in the face of uncertainties as outcomes from management actions and other events become better understood. Careful monitoring of these outcomes both advances scientific understanding and helps adjust policies or operations as part of an iterative learning process. Adaptive management also recognizes the importance of natural variability in contributing to ecological resilience and productivity. It is not a 'trial and error' process, but rather emphasizes learning while doing." (DOI 2009, p. 4)

[3] Conjunctive use is the joint management of surface water and groundwater resources to increase yield and improve regional water reliability.

[4] The California Department of Water Resources (DWR) defines safe yield as the amount of groundwater that can be continuously pumped from an aquifer without adverse impact (DWR 2003). As pointed out by Enion (2013), courts have often interpreted safe yield without regard to instream beneficial use, environmental harm, or other stakeholders.

questions remain about how it will be implemented, the effect that it will have on resolving current and future groundwater conflicts, and whether the plans it mandates will be challenged through adjudications.

The workshop was convened to identify common drivers in groundwater conflicts in California, barriers to resolving these conflicts and possible solutions for moving forward. Held in November 2014, just two months after the passage of SGMA, the workshop also aimed to consider how this new legislation would change the landscape of groundwater conflicts and potential options for resolution, and to bring conflict resolution experts together with groundwater managers and researchers to discuss paths forward. Workshop participants represented a range of sectors, including agricultural users, groundwater managers, water policy experts, water lawyers, groundwater consultants, collaborative water modeling experts and practitioners, mediators, and conflict resolution experts. A full list of attendees can be found in Appendix A.

Prior to the passage of SGMA, the development of groundwater management plans (GMPs) in California was largely voluntary.[5] While a series of legislative actions (AB 255, AB 3030, SB 1938 and AB 359) beginning in the early 1990s provide guidance on the development of these plans, including requirements for public notification and engagement, the voluntary nature of GMPs and their sporadic implementation led to wide variation in plan effectiveness (Nelson 2012). By contrast, SGMA not only mandates the development of groundwater sustainability plans (GSPs) to address undesirable results of groundwater overdraft, it also requires local agencies to consider the interests of "all beneficial uses and users of groundwater…." These users or stakeholders include overlying property owners, municipal well owners (who do not have overlying property rights), public water systems, local land use agencies, environmental users, surface water users, the federal government, Native American tribes in California, disadvantaged communities, and listed monitoring entities. We refer to these interests collectively throughout this report as stakeholders and/or interested parties.

The legislation applies only to the groundwater basins listed in DWR's Bulletin 118 that are identified as high- or medium-priority. Bulletin 118 identifies 515 basins in the state, of which 43 are classified as high-priority and 84 as medium-priority. Collectively, these 127 basins encompass approximately 96 percent of groundwater use in the state and 88 percent of the population (DWR 2014b).

This report summarizes six broad challenges, described below, in resolving groundwater conflicts and achieving sustainable groundwater management in California that were identified during the workshop. Some of these barriers have been addressed with the passage of SGMA; however, its successful implementation will

[5] with exception to Special Act Districts and adjudicated groundwater basins.

require that the state develop effective policy tools and best management practices to guide agencies, stakeholders and interested parties through the process. Besides addressing implementation of the statute, the workshop also discussed potential solutions that could assist in resolving disputes and developing sustainable and consensus-based groundwater management. The major findings of these discussions are summarized in the Key Findings section. Ideas for future research generated by workshop participants can be found in Appendix B.

Challenges and Barriers for Sustainable Groundwater Management

1. Fragmented groundwater management

Until passage of SGMA, California lacked a statewide framework for groundwater management. Rather, groundwater management in California has traditionally focused on local control and regulation, with the goal of promoting local solutions (Nelson 2012). While local control can lead to creative and effective solutions to groundwater management issues (Nelson 2012), it can also result in fragmented management and decreased system flexibility (Sax 2003). In California, a decentralized and localized approach has resulted in nearly 2,300 independent water agencies throughout the state – all with varying degrees of authority to manage groundwater (Nelson 2012).

SGMA represents a significant shift by mandating specific groundwater sustainability goals. However, it maintains the commitment to local control, based on the premise that groundwater resources are most effectively managed at the local or regional level (Cal. Water Code, Uncodified Findings). This focus on local control will make coordination among local agencies critical to avoid continued fragmentation of governance.

SGMA addresses the fragmented nature of groundwater management in California by requiring some degree of basin-focused management. The law does not require a single governing body or management plan for each basin (groundwater sustainability agency (GSA) and groundwater sustainability plan (GSP), respectively), but multiple agencies or plans developed within a basin must be coordinated under one coordination agreement.

Formation of GSAs must occur by June 30, 2017; this is the first significant deadline for groundwater management agencies under SGMA. This first step will require local entities to make many difficult decisions on a variety of governance issues early in the process, including: identifying an existing local agency or combination of agencies as a GSA, or forming an entirely new agency to represent many local agencies and stakeholders; determining the governance structure between multiple GSAs that cover the same basin; figuring out the interaction between the physical boundaries of groundwater basins and GSA management

areas; and engaging stakeholders and interested parties in the GSA formation process (which sets the groundwork and expectations for later engagement in developing the GSP). Most of these decisions involve issues that cross local political boundaries, which heighten the importance of jurisdictional cooperation. Agencies may find it easier to start by negotiating processes (i.e., timelines and agendas) and rules to establish trust among parties before attempting to make the larger governance decisions.

Once formed, GSAs will be required to develop GSPs with measurable objectives and interim milestones by January 31, 2020 or 2022;[6] GSPs must be written to achieve sustainable groundwater management within 20 years of GSP implementation. Regardless of whether a single GSA crosses multiple jurisdictions, or if multiple GSAs manage a single basin, the development of GSPs will require a firm commitment to communication, data sharing and joint decision-making by all agencies involved to ensure that GSPs across an entire groundwater basin jointly achieve sustainability goals.

Additional coordination issues must be considered, as the statute leaves some decisions that will affect groundwater pumping in the hands of county and city agencies. Land use decisions, for example, are unaffected by SGMA, although the statute requires coordination and consultation between land use planning agencies and GSAs to ensure the adequacy of existing and future water supplies to meet land use decisions. However, it does not provide details on how changes in land use zoning or developments should be incorporated into GSPs, nor does it authorize GSAs to limit land use developments based on anticipated water shortages.

Additionally, the legislation does not grant GSAs permitting authority for the construction, modification or abandonment of groundwater wells; rather this authority remains the jurisdiction of local government agencies.[7,8] Close coordination between GSAs and permitting agencies will therefore be essential in order to ensure that groundwater sustainability goals, as established by the GSP, are consistent with the well permitting and land use actions of the local government agencies.

Fragmentation of groundwater management can also limit coordination between different groundwater users and lead to the exclusion of some stakeholders from

[6] High- and medium-priority groundwater basins identified as subject to critical conditions of overdraft must be managed under a groundwater sustainability plan (GSP) by January 31, 2020; all other high- and medium-priority basins have until January 31, 2022 to be managed under a GSP.
[7] In most cases counties issue permits for the construction, modification, or abandonment of groundwater wells. GSAs may request, and the county shall consider, that permit requests are forwarded to GSAs prior to approval.
[8] The county will manage areas of high- and medium-priority basins that are not within the management area of a GSA (referred to by the state as potentially unmanaged areas (PUMAs)). As a result, groundwater basins where counties elect to become the GSA will have all the authorities of a GSA as well as being responsible for issuing groundwater well permits.

the decision making process. SGMA mandates the inclusion of diverse stakeholders in the planning process (discussed on page 6). However, integrating stakeholder interests in ways that enhance both the quality and the durability of the GSP must be worked out.

Finally, fragmented management can make it difficult to assess the effectiveness of an agency or institution's individual management success, particularly when there are many agencies managing the same groundwater basin (Blomquist 1992). Improved coordination between agencies under the GSA governance structure can help to address some of the concerns associated with agency fragmentation and provide opportunities for regional solutions if done in a transparent and concerted manner. However these gains may be undermined by multiple GSAs and GSPs across a single basin, especially if governance agreements are unclear.

While the legislation has deemed agencies governing special act districts as the exclusive GSA within their statutory boundaries (e.g., Santa Clara Valley Water District, Pajaro Valley Water Management Agency),[9] most groundwater basins will need to negotiate the basin's governance structure between multiple local agencies. Because GSA formation is the first step in a series of joint groundwater management decisions, ensuring a successful GSA formation process is likely to be crucial to the successful development and implementation of a GSP. Many agencies will benefit from the use of a third party professional mediator or facilitator[10] during this phase of SGMA implementation, as negotiations that take place during GSA formation are likely to be complex and time consuming, and may be occurring between agencies who have little or no existing relationship (or even hostile relationships, in some cases).

Facilitators can help agencies move through the GSA formation process in several ways (see Box 2). First, they can work with local agencies across a groundwater basin to develop a governance structure that is representative of their basin. Second, they can work with agencies to develop guiding processes, plans and charters for decision-making. These documents and processes can serve as the basis for relationships and decision-making processes during the development and implementation of GSPs. Finally, they can conduct a situation/stakeholder assessment of the basin to help local agencies develop an outreach and engagement plan that is comprehensive, inclusive, feasible and potentially effective at mitigating conflict. If managed correctly, GSA formation can be used as an opportunity to begin to develop trust between agencies and a common understanding of one another's underlying interests. Third-party mediators have

[9] SGMA deems 15 agencies as the exclusive local agencies within their statutory boundaries (Cal. Water Code §10723 (c)). These agencies currently govern special act districts.

[10] Technically, a mediator is a neutral person who helps parties in a dispute reach agreement. A facilitator supports a group to work more effectively, for example by designing meetings or capturing "group memory." In environmental decision making process, the roles of mediators and facilitators can become blurred. We have not made a strict distinction in this report; however, we note the distinction here, as it may become important to individual agencies defining the kind of outside help they could best use.

already been used to facilitate governance structures and develop groundwater management plans in California (see Box 3).

Box 2. Ways mediators and facilitators could help in implementing SGMA

During GSA Formation

- Governance Structure - Help coordinating agencies develop a representative governance structure and determine best fit for their basin.
- Convening Documents – Develop convening documents, charters, a communication plan, and establish engagement and communication protocols.
- Engage Interested Parties Effectively – Perform a stakeholder/situation assessment to provide information on stakeholders, their values and interests, and basin history. This information can be used to anticipate and mitigate conflict, identify opportunities and common ground between stakeholders, and identify the most effective engagement, communication and information sharing forums.

During GSP Development

- Develop Data Collection Goals and Protocols – Develop data collection and modeling protocols jointly to ensure transparency and a common understanding among stakeholders.
- Joint Fact Finding – Work collaboratively with all agencies and stakeholders to define research questions and identify areas requiring additional data or research. Develop a common understanding and language to serve as basis for discussion water management issues.
- Consensus-based Decisions – Work with representative stakeholders to agree on process and negotiate GSP development.
- Engage Interested Parties Effectively – Support the GSA in its public engagement strategy. Ensure GSAs use the input and feedback received through public engagement to inform GSP development, implementation, and associated decision-making.

Box 3. Examples of Recent Facilitated Groundwater Management Plans

Several water agencies throughout the state have taken a proactive role in developing collaborative groundwater management plans that represent a diversity of local stakeholders including local agriculture, municipalities, government agencies, businesses, local water providers and environmental interests. These voluntary plans outline groundwater management goals and objectives, as well as develop a framework to ensure the necessary data collection, management and analysis to achieve these goals. Some examples of groundwater management plans developed using third-party facilitators include the Sacramento Groundwater Authority Management Plan (which evolved out of the Sacramento Water Forum), the Sonoma Valley Groundwater Management Plan, and the Santa Rosa Plain Groundwater Management Plan.

It is important to note that facilitators and mediators are not subject to specific licensing requirements; as a result, it will be important that agencies seeking these services work with experienced practitioners. Workshop participants suggested that the state develop a list of facilitators and mediators who have experience working on groundwater or natural resource issues. This list of neutral mediators would be similar to court-maintained lists of mediators who can be used to resolve disputes. Another possible source of third party assistance is the U.S. Institute for Environmental Conflict Resolution's roster of facilitators and mediators.

Additional Questions

- What are the comparative advantages of various methods and governance structures (joint powers authority, memorandum of understanding, contracts etc.) for coordinating GSAs and GSPs to achieve sustainability goals? How can potential conflicts between agencies be prevented?
- How can GSAs ensure coordination with land use planning agencies and well permitting agencies to achieve consistent actions and outcomes?
- How can multiple GSPs in a single basin be effectively evaluated? How can multiple GSAs determine and assign appropriative adaptive actions if basin-wide objects are not achieved?
- How can we ensure all interests are heard and incorporated into GSAs and GSPs in a meaningful way? What are the means of incorporating stakeholder and interest groups not traditionally included in groundwater planning into SGMA planning process (e.g., unincorporated well owners, environmental groups, tribes, disadvantaged communities)?
- What factors should influence the design of planning processes in particular basins?

2. Voluntary groundwater management

Groundwater management in California was largely voluntary until the passage of SGMA. The main incentive that the state offered to local groundwater entities was access to state funding if a groundwater management plan was in place. Several bills (AB3030, SB1938, and AB 359) provided a common framework for the development of voluntary GMPs, which will now form the basis for GSPs required for all high- and medium-priority groundwater basins under SGMA.

While GMPs were a first step in groundwater management in California and a means to effective management in some basins, Workshop participants discussed some of the challenges of voluntary management plans. These include: a lack of urgency and consequence, minimal guidance, few authorities or powers, inadequate funding and inconsistency in plan development and effectiveness (Nelson 2012).

SGMA is a more powerful legal tool for sustainable groundwater management. It introduces the threat of state intervention if groundwater basins are not moving toward sustainable groundwater management. (Criteria for state intervention will be discussed in the following section on Legal Uncertainty.) It also provides GSAs with a breadth of tools and authorities to achieve sustainability goals, including adopting new rules or regulations, acquiring water rights, requiring well registration and/or metering, limiting groundwater extractions, and imposing fees.

A credible threat of state intervention will be critical to the success of SGMA. If groundwater agencies do not believe that the state is willing to step in and take over management of the basin if deadlines or objectives are not being met, then in certain basins there will be limited motivation or long-term commitment to take the difficult actions required to achieve sustainable management goals. It will also be critical that DWR and the State Water Resources Control Board (SWRCB) establish clear criteria for evaluating GSPs and step in with interim management plans when these criteria are not sufficiently met.

The state backstop provides a means to move beyond stalemate in local conflicts by incentivizing local action. Local agencies can legitimately point out the politically unpalatable possibility of state intervention if local entities fail to act; most will prefer to develop local solutions rather than accept state intervention and the possibility of worse outcomes.

Finally, it should be noted that 388 of California's groundwater basins are currently categorized as low- or very low-priority. While these basins are encouraged to develop GSAs and GSPs under the new legislation, these actions are not required. Unconstrained pumping of groundwater in these low priority basins could lead to adverse impacts in the future - something the current legislation does not address.

Additional Questions

- Will the threat of state intervention provide the motivation required to develop and implement GSPs that result in groundwater sustainability? What does the state backstop look like and will the state actually use it?
- How can the state balance local control with basin-wide sustainable management objectives?
- How can the state backstop best be used to aid the resolution of local conflicts?

3. Legal uncertainty in SGMA

The primary goal of SGMA is to sustainably manage all high- and medium-priority groundwater basins to avoid "undesirable results," which the law defines as:

- Chronic lowering of groundwater levels indicating a significant and unreasonable depletion of supply if maintained;
- Depletions of surface water that have significant and unreasonable adverse impacts on beneficial water users;
- Significant and unreasonable:
  - reduction of groundwater storage;
  - seawater intrusion;
  - degraded water quality; and/or
  - land subsidence.

Areas of legal uncertainty under SGMA include how the terms "undesirable results" and "significant and unreasonable" impacts will be interpreted and used, potentially fostering different interpretations and disputes in court.

The threat of state intervention plays a central role in this legislation. In the event that local agencies are not meeting interim GSP milestones or are experiencing "significant and unreasonable" impacts, the SWRCB can deem a GSP inadequate and step in with an interim groundwater management plan until the development of an adequate local GSP has been approved. However, the lack of clear criteria on what constitutes "significant and unreasonable" impacts, as well as questions about the state's willingness and ability to take over management of a probationary basin, have the potential to undermine the threat of state intervention when plans are inadequate for achieving sustainable management.

The legislation cites three main triggers for deeming a groundwater basin as probationary: 1) A GSA has not been elected by June 30, 2017; 2) A GSP has not been implemented by January 31, 2020 or January 31, 2022, depending on the basin's categorization; and 3) The GSP is deemed inadequate or is not being implemented in a manner that is likely to achieve sustainability goals. The first two triggering actions would seem to involve no exercise of discretion by the SWRCB, but this is not the case: deadlines not met as a result of litigation are excused (Cal.

Water Code § 10735.2 (d)). This creates a potential incentive for litigation, particularly where the measures in the GSP are costly or in basins with an existing history of conflict.

The phrase "significant and unreasonable" is intrinsically flexible and designed to allow for variations in local conditions. The degree to which impacts are "significant and unreasonable" may be defined by local agencies during the development of GSPs and serve as a means of bringing interested parties together. In this instance, the state agencies responsible for evaluating GSPs will need to more clearly define the criteria that constitute "significant and unreasonable" impacts to ensure that they are used consistently in the evaluation of GSPs. Ultimately, the criteria defining "significant and unreasonable" impacts probably will be decided by the courts during cases appealing the state's intervention. Hopefully, in basins where interested parties reach a common understanding, such intervention and appeals can be avoided.

Additional Questions

- What constitutes a "significant and unreasonable" impact under SGMA?
- What are the criteria for deeming a GSP inadequate or unlikely to achieve sustainability goals?
- Will the state have the resources and will to intervene consistently when groundwater basins are not meeting sustainability goals?
- What role will key terms in the statute play in groundwater conflicts in local basins?

4. Property rights and existing legal rights to water

The new statute grants GSAs the authority to limit groundwater extractions; however, because the statute does not affect existing water rights or property rights, GSPs that include any reductions in groundwater pumping must respect California's complex groundwater priority rights (see Box 4). The murky system of correlative, appropriative, and prescriptive legal rights held by current water users could act as a constraint on the ability of GSAs to effectively manage groundwater and serve as an additional source of conflicts. The lack of clarity with respect to the property rights system means that groundwater users could assert that measures in a GSP violate their property rights.

Supplementing water supply with imported water or other "new" water (such as recycled waste water) can help to avoid groundwater conflicts. However, regions without access to supplemental water supply may have to mandate pumping reductions. Users then could assert claims that the GSP violates their property rights, potentially by filing for a groundwater adjudication.

Box 4. Groundwater rights in California

Groundwater rights in California have evolved through case law. Property rights rulings in groundwater adjudications have created three basic categories of rights: correlative (or overlying) rights, appropriative, and prescriptive. These rights are not equal but are based on priority as established by the California Supreme Court in the appeal of the San Fernando Valley basin adjudication.

Landowners overlying a groundwater aquifer have "overlying" rights to pump groundwater from the basin for use within the basin. These rights are correlative, meaning that all overlying pumpers share the basin's safe yield.

Appropriative rights to groundwater are available if there is surplus water after overlying users' extractions. This water can be used outside the basin. Appropriative rights, like surface water rights, are considered first in time, first in right. Municipal use is considered appropriative, even if the city overlies the basin. Prescriptive groundwater rights occur when a user pumps more than the basin's safe yield for more than five consecutive years. Cities that have been withdrawing water in excess of safe yield often have prescriptive water rights.

The relationship between groundwater adjudication processes through the courts and SGMA was a major topic of discussion at the workshop. Because the statute does not provide guidance on how to allocate groundwater based on property rights or the priority that these various rights should receive, GSPs remain vulnerable to adjudication if groundwater pumpers believe there has been a violation of their property rights (a "taking") or are unhappy with the terms of the GSP.

Under California law (and unchanged under SGMA), the only way to clarify the priority of different water users in a basin and clearly establish their respective legal rights to a certain quantity of water is through general adjudication of the basin. In practice, past adjudications have resulted in settlement agreements, though the extent to which particular issues were decided through adversarial process in court varies widely depending on the adjudication. Because only 24 of the state's 515 basins have been adjudicated and many of the cases took place in the latter half of the past century (Figure 2), it is difficult to know how the experience of past groundwater adjudications will translate to groundwater basins under SGMA.

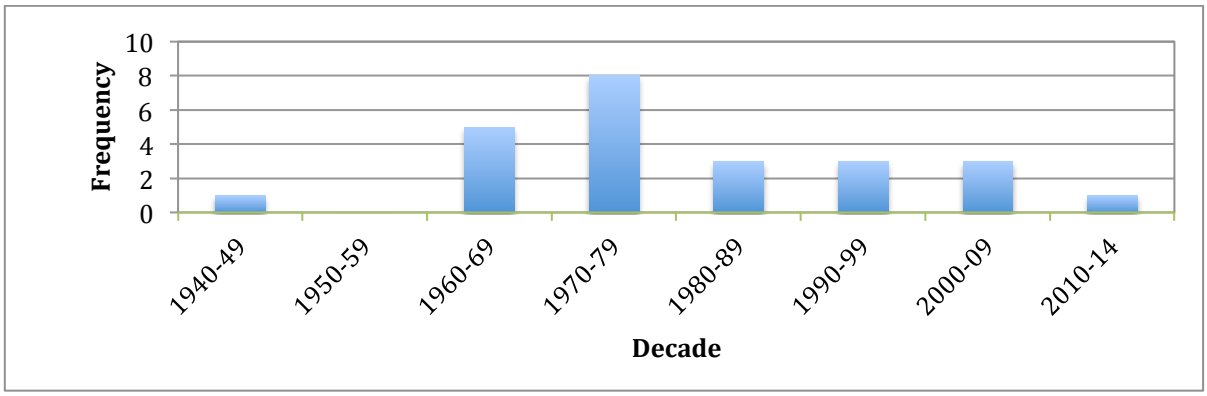


Figure 2. Frequency of groundwater adjudications in California by decade.

At best, past adjudications have a mixed record of success[11] in California. On one end of the spectrum, the example of Seaside Basin on the Monterey Coast (completed in 2006) suggests adjudication has the potential to efficiently produce a durable, legally binding allocation outcome that takes into account the needs of multiple parties (e.g., agricultural users, municipalities, domestic users, water utilities). Seaside was adjudicated in three weeks after an extended period of negotiation and discussion. On the other end of the spectrum is the Mojave Basin, where a protracted legal settlement took 30 years and still ended up in the California Supreme Court. The Mojave is the example most often cited as evidence of the inefficiencies and astronomical costs of adjudication.

The potential advantages and disadvantages of adjudication are listed in Table 1. Although adjudications have the potential to be expensive and drawn out legal proceedings that do not meet the interests of all stakeholders, under California law only the courts have the power to clarify legal rights to water. Until those rights are clarified in court, any groundwater management scheme, including a GSP, is in jeopardy of being undermined by users claiming that the scheme violates their property rights. How to deal with the underlying risk of adjudication is a significant issue facing the state.

[11] The success of an adjudication can be defined using a variety of metrics (e.g., process, outcome etc.). In this example we are referring to the success of the adjudicatory process.

Table 1. Potential advantages and disadvantages of adjudication for groundwater management

Potential Advantages	*Potential Disadvantages*
• Creates binding property rights (usually) • Creates legal certainty • Quantifies the amount of water to which each user is entitled • Evidence procedure used by court can lead to shared information base • Can allow for resolution of related but separate issues (e.g., allocation of storage rights in aquifer) • Flexibility (i.e., may allow for solutions not available by other means such as market-based trades or fees) • Can result in continuing court jurisdiction over the basin**	• Often time consuming (sometimes *very* time consuming) • Often very expensive. (However, the cost of negotiated or non-court settlements in basins could be similar.) • May not adequately account for interests of those who do not hold water rights; questions of standing remain • Issues that parties do not reach agreement on during settlement process are ultimately decided by a judge • Legal standard for deciding groundwater cases from previous case law remain unclear, creating legal uncertainty and perhaps incentives for parties to delay settlement • Civil judges often lack technical expertise • Can result in continuing court jurisdiction over the basin**

**Depending on how this continuing jurisdiction was structured, this is a potential pro or con.

One solution discussed during the workshop was a streamlined adjudication process. Participants discussed a variety of forms that this process could take, from water-centric courts and judges, where legal proceedings could move through a court more quickly; to negotiated agreements developed through planning overseen by GSAs; or in other venues later made legally binding by the filing of an adjudication. Variations of hybrid arrangements on the spectrum from negotiation to adjudication are presented in Figure 3. Ultimately GSPs must account for existing water rights, create predictable outcomes, and incorporate the views of a range of interested parties.

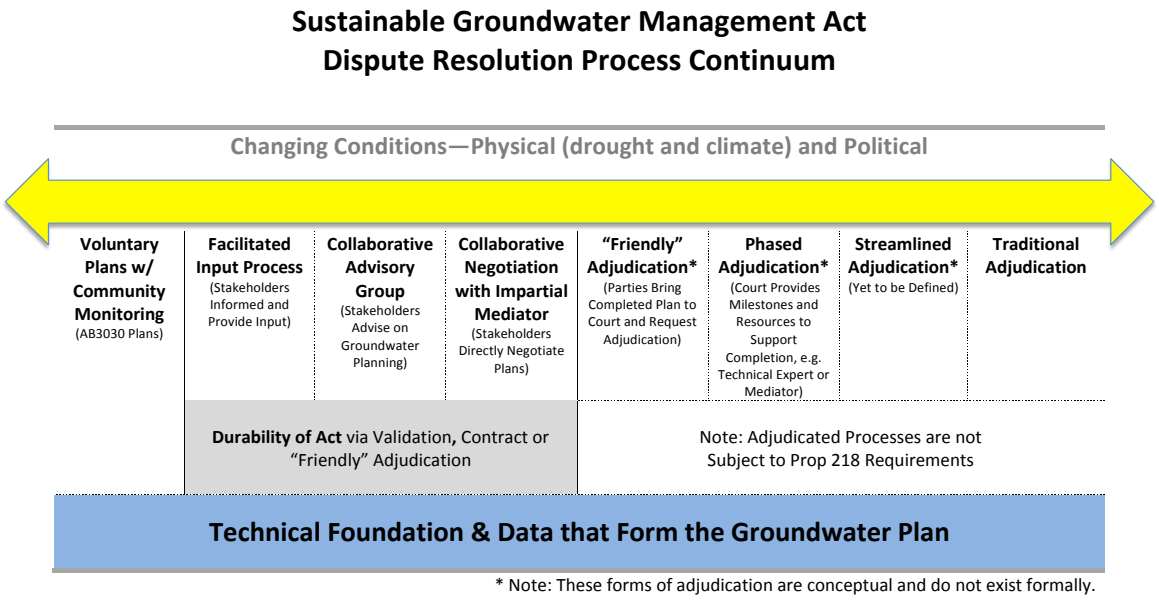


Figure 3. A continuum showing groundwater management planning processes available in California under the Sustainable Groundwater Management Act. Starred processes are conceptual processes discussed during the meeting that do not currently exist. Developed by Gina Bartlett of the Consensus Building Institute, 2014.

The risk is that agencies or individuals who are not happy with the GSP or consider the reductions in pumping mandated by the GSP as a "taking" of property rights may file an adjudicatory action on the groundwater basin and derail implementation of SGMA. As a result, it will be imperative to the development of successful GSPs that GSAs: 1) engage all interested parties early and in a meaningful way; 2) demonstrate their commitment to supplementing groundwater supply through conjunctive use and supplemental supplies wherever possible; and 3) ensure that GSPs are developed based on transparent information and in a manner that promotes consensus between all groundwater users.

Additional Questions

- What is the interplay between adjudication and SGMA? Are there situations in which adjudication might be preferable to a GSP developed under SGMA or vice versa?
- How can we ensure that GSPs are durable, with predictable outcomes?
- What tools have been used successfully in past groundwater adjudications to achieve safe yield (production, payment regimes, etc.)?
- What are the most effective tools for incorporating stakeholders and interest groups into the adjudication process (environment, tribal, disadvantaged communities)?

5. Data, information, models and dissemination of data

Implementation of SGMA will require making decisions in the face of uncertain data and policy consequences,[12] particularly as climate change complicates our ability to make future forecasts based on past trends (Mora et al. 2013). There are no clear rules about what degree of uncertainty is acceptable —to water users, to agencies with differing mandates, and to courts who might ultimately have to adjudicate rights in basins and make decisions on what constitutes "significant and unreasonable" impacts. Some participants considered data scarcity or uncertainty to be a significant issue, while others were less concerned about these problems compared to other pressing challenges.

The lack of data is sometimes used as a stalling tactic by those who have a vested interest in maintaining the status quo (i.e., those inclined to continue to pump when a basin is in overdraft). A focus on data and models can foster "dueling experts," which can also promote conflict and delays. This "competing experts" dynamic can be exacerbated by the adversarial structure of the civil courts, where presenting conflicting expert testimony is a well-accepted practice. In such cases, it can be difficult for judges to make a ruling on which expert's model should be considered as the "truth."

Groundwater data and numeric groundwater models[13] are necessary components for informed groundwater management decisions; however, because of the expertise needed to analyze these data, they also have the potential to create divisions based on interpretation. Therefore, it will be crucial that GSAs address issues of "dueling experts" proactively. Conflict resolution practice presents well-accepted methods of doing this – methods designed to produce information that all parties trust. These methods include joint-fact finding, where parties agree about the questions they need to have answered and together commission independent parties to conduct those studies (Ehrman and Stinson 1999). Other options include a representative technical advisory committee (TAC) or neutral third-party researchers (e.g., from academic institutions or the U.S. Geological Survey). Such experts can provide objective information on groundwater basin characterization, monitoring, and groundwater modeling to inform groundwater management decisions.

Groundwater managers face many difficulties in managing groundwater resources due to the increasing uncertainty of local and regional water supplies. Regional

[12] Characterization of scientific and socio-economic certainty can play an important role in the decision making process (Lempert et al. 2004). The Fifth Assessment Report of the Intergovernmental Panel on Climate Change (IPCC 2014) uses five qualifiers to convey the degree of confidence (or certainty) in a particular finding to non-experts, these are: very low, low, medium, high and very high. These qualifiers synthesize the evaluation of evidence and the degree of agreement in a finding.

[13] We use the term numeric groundwater models to refer to a computer model that solves groundwater flow equations. These models can be used to simulate different groundwater management decisions by changing the input data or model assumptions (Reilly and Harbaugh 2004).

water management and conjunctive use are two strategies often used to improve efficiency and reduce water supply vulnerability. Integrating adaptive management strategies into water planning efforts is also increasingly critical. Such adaptive management is only possible with sufficient, coordinated baseline data and ongoing monitoring to iteratively inform decision-making (EPA and DWR 2011). Developing robust data collection, monitoring, sharing, and modeling protocols that are coordinated across an entire groundwater basin will help to maximize regional adaptive capacity.

State guidance on best management practices for data collection, monitoring and storage, as well as clear criteria for the minimum groundwater monitoring data necessary for sustainable groundwater management is crucial. This guidance would provide local jurisdictions with the flexibility to tailor local monitoring networks to local groundwater and subsurface conditions, while meeting minimum data requirements.

Numeric groundwater models can be a powerful tool for sustainable groundwater management. However, for a variety of reasons these models do not always succeed at creating a shared understanding of the facts that can then be the basis for decision-making. These reasons include: confusing or non-intuitive model outputs, a general distrust of models by non-experts (because they are not well understood), the power dynamic groundwater models establish (e.g., stakeholders need to interact with model results though experts), and a lack of understanding around the uncertainties of model outputs. Additionally, there are several different numeric groundwater models used throughout the state; this can make collaboration challenging between agencies using different models.

Coordinating groundwater models, data inputs and data projections is important between adjacent basins to ensure consistency in groundwater planning efforts. But there is often a reluctance to switch to a different groundwater model once a basin has already invested time, money and energy into an existing model with which local parties are familiar. Additionally, many groundwater agencies do not have in-house groundwater modeling expertise; they must hire consultants to run groundwater models. Additional studies comparing numeric groundwater models to one another (similar to the study done by Harter and Morel-Seytoux (2013) for California's Central Valley) would be helpful for agencies to select which numeric groundwater model to use.

Collaborative models[14] or decision support tools incorporate information from existing numeric models, monitoring networks and other sources to guide stakeholders through a range of resource development and management options

[14] We use the term collaborative models to refer to models that integrate information from a variety of sources to model complex systems, generate alternative management scenarios, integrate different individual or group goals, and foster consensus-based management decisions (Technology and ECR Coordinating Committee 2011, 1).

(Cravens 2014). These models have been used extensively in surface water management, and focus on the development of consensus-based management goals, performance measures, data, and methods (Bourget 2011). Two examples of collaborative surface water models include: a) Operational Analysis and Simulation of Integrated Systems (OASIS) by Hydrologics, which has been used for a variety of water management projects, including as a dispute resolution tool (Rivera and Sheer 2013); and b) the Water Evaluation and Planning (WEAP) model developed by the Stockholm Environmental Institute's U.S. Office for integrated watershed assessments used in both the U.S. and internationally. WEAP was recently used to assess changes in groundwater storage resulting from climate change in Sirhind, India (Nayak et al. 2015).

Box 5. What is collaborative modeling?

Collaborative modeling is a form of decision support that integrates technical computer models with process and facilitation skills to guide stakeholders through complex management decisions involving scientific data. During the collaborative modeling process, representative stakeholders, decision makers and scientific experts work jointly to develop and test a model that is representative of the system they are trying to manage. The model is often run live in sessions, allowing real-time interaction and testing of alternatives. This keeps the discussions "reality-based" instead of having stakeholders rely solely on intuition when seeking mutually agreeable solutions.

The process is designed to ensure data and model transparency and accessibility while building a common level of technical understanding and identifying common management goals. Once developed, these models may be used to create a better understanding of existing conditions and potential futures, for management and decision support, as well as for education and outreach.

Collaborative models are well suited to complex, conflict-laden decision-making processes involving a variety of willing stakeholders. As a result, their use is becoming increasingly common in surface water management. Tailoring the collaborative modeling process to groundwater management and conjunctive use applications presents a significant opportunity for improved water management decisions.

While collaborative models focus stakeholders on joint management decisions to achieve mutually agreed upon goals, one of the most important benefits of collaborative modeling is the way it allows participants to jointly "play" with various management scenarios and together, observe and discuss the range of outcomes. These models have potential to positively impact groundwater allocation processes.

Additional Questions

- What data are necessary for groundwater management decisions? How does the cost of obtaining that information compare to its value to groundwater management?
- Are there changes in the legal framework governing the collection and use of data that would improve implementation of SGMA?
- Are there achievable improvements to groundwater models that would improve their utility in management and reduce the chances of conflict?
- How can information sharing across agencies be encouraged (i.e., in the absence of formal collaborative agency formation)? How can we standardize data collection and sharing?
- Can technical advisory committees (TACs) help overcome the "dueling scientific experts" dynamic? What are the characteristics of a good TAC?
- How can data and science be more accessible to non-technical stakeholders? Are there ways to communicate data differently (e.g., visually) that would enhance its value, promote broader understanding among stakeholders, and improve the decision-making process? How can the "play" dynamic best be fostered?

6. Funding and support

Many meeting participants expressed concern about how local agencies and groundwater managers with whom they work will pay for the staff and outside expertise required for successful implementation of SGMA. The tight deadlines for implementation are expected to stress existing personnel and, in most cases, will necessitate additional staff to help with the administrative, outreach and technical components required by the law. Many basins will require expertise from outside the agency to facilitate GSA formation, develop and lead stakeholder outreach processes, and design and implement the appropriate groundwater monitoring protocols and numeric groundwater models necessary for ensuring that sustainability goals can be achieved within the 20-year sustainability timeframe.

The law authorizes GSAs to levy fees to pay for groundwater management; however, many actions requiring substantial investments of both time and money will be necessary prior to the implementation of groundwater service fees or other administrative costs. Therefore, many agencies are worried about how they will fund the formation of a GSA that will be responsible for implementation of the GSP and its corresponding service fees. With such high upfront investment required, the cost issue might be one of the most significant challenges to using SGMA to resolve groundwater conflicts.

In November 2014, California voters passed Proposition 1, the "Water Quality, Supply and Infrastructure Improvement Act of 2014." This general obligation bond

provides $100 million to develop and implement GSPs (Cal. Water Code § 79775). A portion of this funding may also be available for the formation of GSAs. However, given that the legislation requires the development of GSAs and GSPs in approximately 100 groundwater basins throughout the state (127 high- and medium-priority groundwater basins less the 29 adjudicated actions identified in the legislation), the amount of funding will not be adequate to support the process in all basins requiring a GSP. Meeting participants underscored the need for access to consistent funding sources for long-term planning and infrastructure projects.

Another topic discussed at the workshop was the need for guidance from state agencies to support implementation of SGMA. There was a general desire for more information, case studies and policy recommendations to guide local agencies through the process of GSA formation; stakeholder outreach and engagement; GSP development and implementation; and coordination of management actions between agencies. Agencies would also like guidance on the technical aspects of groundwater management, including best management practices for data collection, monitoring, storage and sharing; basin characterization; numeric groundwater models; and improved understanding of surface water-groundwater interactions.

Additional Questions

- How will GSA formation be funded?
- What funds will be available for the development of long-term planning and infrastructure projects?
- What funding options are available to agencies to implement their mandate?
- How can agencies make the best use of scarce resources (including technical resources, funds, training, education, and communication)? What other resources are needed to implement the law? Are they available? How should agencies prioritize resources?
- What role can water markets play in addressing these questions?

Moving Forward: Summary of Key Findings

Key findings that could be undertaken in the next three years to streamline or support implementation of SGMA are summarized below.

1. **State intervention -** The Department of Water Resources (DWR) and the State Water Resources Control Board (SWRCB) need to develop clear criteria for how the state will intervene and enforce in groundwater basins not achieving sustainability goals.
2. **Groundwater property rights –** Groundwater property rights in California should be clarified, predictable and transferable. Since SGMA does not change property rights, any GSP that is perceived to violate these rights will risk legal challenge. GSAs thus need to prioritize engagement of all interested parties. At the same time, the legislature or courts should consider means to make GSPs developed under SGMA legally binding.
3. **Facilitated support for SGMA implementation -** The state should encourage and support the use of experienced groundwater facilitators and mediators who can help with SGMA implementation, particularly for Groundwater Sustainability Agency (GSA) formation. State funding for facilitated support would help.
4. **Collaborative processes -** DWR and the SWRCB, in conjunction with research institutions and mediators, should develop best management practices for collaborative processes. Materials could include templates, courses and educational materials. Guidance and tools for evaluating the applicability of existing collaborative approaches for SGMA compliance and improving their usefulness for groundwater allocation decisions would also be very helpful.
5. **Funding -** The state should provide consistent, accessible funding for GSA formation and GSP development and implementation. These funds should be tied to specific and measureable goals and timelines.
6. **Case studies -** Research institutions, state agencies, and public policy centers should develop case studies from California, other states and other countries that can serve as examples of sustainable groundwater practices.

SGMA represents a significant step forward in addressing conflicts over groundwater in California and moving toward its sustainable management. Yet the success of the legislation ultimately depends on active participation, guidance and an ongoing commitment to the process from numerous entities, including state agencies, water lawyers, mediators, groundwater policy experts, local groundwater agencies, agricultural users, stakeholders and interested parties, and social and environmental justice groups. The participation of all of these parties and more will be needed to ensure that local groundwater agencies have the tools and resources necessary to move from legislative requirements to effective and sustainable groundwater management that is capable of adapting to changing technological, climatic, social and environmental conditions.

References

Blomquist, W. A. (1992). *Dividing the Waters: governing groundwater in southern California*, ICS, Lanham, MD.

Bourget, L. (ed.) (2011). *Converging Waters: Integrating Collaborative Modelling with Participatory Processes to Make Water Resources Decisions.* IWR Press: Alexandria, VA.

Cravens, A. (2014). *Evaluating software in environmental conflict resolution*. [Dissertation] Stanford University: Stanford, CA.

Diffenbaugh, N.S., D.L. Swain, and D. Touma. (2015). Anthropogenic warming has increased drought rist in California. *PNAS*, 112(13):3931-3936. doi:10.1073/pnas.1422385112.

Doll, P., H. Hoffmann-Dobrev, F.T. Portmann, S. Siebert, A. Eicker, M. Rodell, G. Stassberg, and B.R. Scanlon. (2012). Impact of water withdrawals from groundwater and surface water on continental water storage variations. *Journal of Geodynamics,* 59-60: 143-156. doi:10.1016/j.jog.2011.05.001

[DOI 2009] Williams, B. K., R. C. Szaro, and C. D. Shapiro. (2009). *Adaptive Management: The U.S. Department of the Interior Technical Guide*. Adaptive Management Working Group, U.S. Department of the Interior, Washington, DC. http://www.doi.gov/initiatives/AdaptiveManagement/TechGuide.pdf

[DWR 2014a] California Department of Water Resources. (2014). *Public Update for Drought Response Groundwater Basins with Potential Water Shortages and Gaps in Groundwater Management*, California Department of Water Resources, Sacramento, CA.

[DWR 2014b] California Department of Water Resources. (2014). *California Groundwater Elevation Monitoring: Basin Prioritization*, California Department of Water Resources, Sacramento, CA.

[DWR 2013] California Department of Water Resources. (2013). *Water Action Plan, Update 2013: Volume 1 – The Strategic Plan, Chapter 3. California Water Today*, California Department of Water Resources, Sacramento, CA.

[DWR 2003] California Department of Water Resources. (2003). *California's Groundwater: Bulletin 118, Update 2003,* California Department of Water Resources, Sacramento, CA.

Ehrman, J.R., and B.L. Stinson. (1999) Joint Fact-Finding and the Use of Technical Experts. In: *The Consensus Building Handbook.* [Susskind, L., McKearnan, S., and J. Thomas-Larmer (eds.)] Sage Publications, Thousand Oaks, CA.

Engle, N.L., O.R. Johns, M.C. Lemos, D.R. Nelson. (2011). *Integrated and Adaptive Management of Water Resources: Tensions, Legacies, and the Next Best Thing.* Ecology and Society, 16(1):19.

Enion, M.R. (2013). Allocating Under Water: Reforming California's Groundwater Adjudications. *Pritzker Briefs, Policy Brief No. 4*. September, 2013.

[EPA and DWR 2011] Environmental Protection Agency Region 9 and the California Department of Water Resources. (2011), in partnership with: U.S. Army Corps of Engineers South Pacific Division, Resources Legacy Fund, and the U.S. Army Corps of Engineers South Pacific Division, and the Environmental Protection Agency Office of Resarch and Development. *Climate Change Handbook for Regional Water Planning,* Prepared by CDM under EPA Contract Number EPA099BOA002.

Griffin, D. and K.J. Anchukaitis. (2014). How unusual is the 2012-2014 California drought? *Geophysical Research Letters*, 41:9017-9023. doi:10.1002/2014GL062433

Hanak, E., J. Lund, A. Dinar, B. Gray, R. Howitt, J. Mount, P. Moyle, and B. B. Thompson. (2011). *Managing California's Water: From Conflict to Reconciliation,* Public Policy Institute of California, San Francisco, CA.

Harter, T., and H. Morel-Seytoux. (2013). Peer Review of the IWFM, MODFLOW and HGS Model Codes: Potential for Water Management Applications in California's Central Valley and Other Irrigated

Groundwater Basins. *Final Report, California Water and Environmental Modeling Forum*, August 2013, Sacramento, CA.

IPCC. (2014). Summary for policymakers. In: *Climate Change 2014: Impacts, Adaptation, and Vulnerability. Part A: Global and Sectoral Aspects*. Contribution of Working Group II to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change [Field, C.B., V.R. Barros, D.J. Dokken, K.J. Mach, M.D. Mastrandrea, T.E. Bilir, M. Chatterjee, K.L. Ebi, Y.O. Estrada, R.C. Genova, B. Girma, E.S. Kissel, A.N. Levy, S. MacCracken, P.R. Mastrandrea, and L.L.White (eds.)]. Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA.

Lempert, R., N. Nakicenovic, D. Sarewitz, and M. Schlesinger. (2004). Characterizing climate-change uncertainties for decision makers. *Climatic Change*, 65:1-9.

Mora, C., A.G. Frazier, R.J. Longman, R.S. Dacks, M.M. Walton, E.J. Tong, J.J. Sanchez, L.R. Kaiser, Y.O. Stender, J.M. Anderson, C.M. Ambrosino, I. Fernandez-Silva, L.M. Giuseffi, and T.W. Giambelluca. (2013). The projected timing of climate departure from recent variability. *Nature*, 105:183-187. doi:10.1038/nature12540.

Morris, B. L., A.R.L. Lawrence, P.J.C. Chilton, B. Adams, R.C. Calow, and B.A. Klinck. (2003). Groundwater and its Suseptibility to Degradation: A Global Assessment of the Problem and Options for Management. *United Nations Environment Programme (UNEP) Early Warning and Assessment Report Series, RS 03-3.* Nairobi, Kenya.

Nayak, P.C., R. Wardlaw, A.K. Kharya. (2015). Water balance approach to study the effects of climate change on groundwater storage for Sirhind command area in India. *International Journal of River Basin Management*, doi:10.1080/15715124.2015.1012206.

Nelson, R.L. (2012). Assessing local planning to control groundwater depletion: California as a microcosm of global issues. *Water Resources Research*, 48: W01502. doi:10.1029/2011WR010927.

Nelson, R.L. (2014). *Groundwater Wells Versus Surface Water And Ecosystems: An Empirical Approach To Law And Policy Challenges And Solutions*. J.S.D. Dissertation, Law School, Stanford University, Stanford, CA.

Pahl-Wostl, C. (2007). Transitions towards adaptive management of water resources facing climate and global change*. Water Resources Management*, 21:49-62. doi.10.1007//s11269-006-9040-4.

Reilly, T.E, and A.W. Harbaugh. (2004). *Guidelines for Evaluating Ground-Water Flow Models*. Scientific Investigations Report 2004-5038.

Sax, J.L. (2003). We don't do groundwater: A morsel of California legal history. *University of Denver Water Law Review*, 6(2), 269-317.

Swain, D.L., M. Tsaing, M. Haugen, D. Singh, A. Charland, B. Rajaratnam, and N.S. Diffenbaugh. (2014). In: *Explaining Extremes of 2013 from a Climate Perspective*. [Herring, S.C., M.P. Hoerling, T.C. Peterson, and P.A. Stott, (eds.)]. Bulletin of the American Meteorological Society, 95(9): S3-S7.

Technology and ECR Coordinating Committee. (2011). *Guiding Principles for the Use of Technology in ECR Processes.* Created by the Technology and ECR Coordinating Committee, with support from the U.S. Institute for Environmental Conflict Resolution and the U.S. Department of the Interior's Office of Collaborative Action and Dispute Resolution, June, 2011.

Rivera, M.W., and D. Sheer. (2013). Computer Aided Negotiation and River Basin Management in the Delaware. In: *Water Resources Systems Analysis Through Case Studies: Data and Models for Decision Making.* [Watkins, D.W. (eds.)]. American Society of Civil Engineers, Reston, VA.

Appendix A. GW Dispute Resolution Workshop Participant List

Name	Organization Name
Newsha Ajami	Water in the West, Stanford University
Mary Bannister	Pajaro Valley Water Management Agency
Gina Bartlett	Consensus Building Institute
Bushra Bataineh	Water in the West, Stanford University
Bill Blomquist	Indiana University-Purdue University Indianapolis
Virginia Cahill	UC Davis
Janny Choy	Water in the West, Stanford University
Amanda Cravens	Martin Daniel Gould Center for Conflict Resolution Program, Stanford University
Marcelle DuPraw	CSUS Center for Collaborative Policy
Erik Ekdahl	State Water Resources Control Board, Groundwater Management Program
Barry Epstein	Allen Matkins
Jason Gershowitz	Kearns & West
Andrew Girvin	Palantir Technologies
Burke Griggs	Water in the West, Stanford University
Jeff Loux	UC Davis Extension
Jan Martinez	Martin Daniel Gould Center for Conflict Resolution Program, Stanford University
Russell McGlothlin	Brownstein, Hyatt, Farber, & Schreck
Tara Moran	Water in the West, Stanford University
Rebecca Nelson	Water in the West, Stanford University
Tim Parker	Parker Groundwater
Debra Perrone	Water in the West, Stanford University
David Purkey	Stockholm Environment Institute-US Center
Jack Rice	California Farm Bureau
Melissa Rohde	Water in the West, Stanford University
Daniel Sheer	HydroLogics, Inc.
Leon Szeptycki	Water in the West, Stanford University
Buzz Thompson	Woods Institute for the Environment, Stanford University
Daniel Wendell	The Nature Conservancy of California
Anna West	Kearns & West
Derrik Williams	HydroMetrics WRI
Kate Williams	California Water Foundation

Appendix B. Comprehensive research opportunity list

The final session of the conference involved participants brainstorming about specific projects that universities, non-governmental organizations, policy centers, and others could contribute to address the barriers described earlier. These ideas represent concrete suggestions of work to be done that moves the more general discussion forward. The full list is reported here.

Note: This list includes both research questions to be answered and suggestions for tools/guides/outputs to produce.
Surveys and case studies were identified as general priority categories

Support GSA Formation
Ideas in this category were identified as priority areas to pursue by the group

- Track the evolution of groundwater basins in order to later do retrospective analysis of GSA formation.
- Provide overview of options for governance structures under the GSA, including pros and cons of each and case studies of existing structures.
- Develop a toolkit or template of common governance structures for agencies to follow.
- DWR needs to provide clear expectations on agency formation; universities could help develop this guidance.

Use Facilitated Processes to Develop GSPs
This was identified as a priority area by the group

- Use interactive 'games' or collaborative modeling processes to guide agencies and stakeholders through various groundwater management scenarios.
- Enlist students from various universities to do statewide surveys for stakeholder assessment (eg., Who should be included in GSPs, what would they bring to the table, what are the best methods to engage them?). Output could be video format.
- Use stakeholder assessment results to develop performance metrics.
- DWR (or someone) needs to provide clear expectations on bill implementation (technical requirements, etc.)
- State board needs to provide a real and concrete threat of state takeover and the criteria that will cause it.

Legal/Policy

- Property rights reform
- Guidance or model rules on how to integrate groundwater and land use planning
- Guidance for developing and integrating adaptive management strategies (both under GSPs and under adjudication)
- Assist DWR in development of regulations and BMPs
- What do agencies need to implement DWR's BMPs? Categorize the complexities

Learn from Past Adjudications to Streamline or Redesign Adjudication Process

- Guide on past adjudications, which could include:
  - Lessons learned. What worked? What didn't?
  - Which issues take up most of the time and energy? Which are meaningful vs wasteful to final agreements?
  - Case studies looking at implementation of past adjudications and how the structure of the agreement influenced durability of the process
  - How processes have differed with different compositions of the watermaster (linked to policy guidance on watermaster design)
  - List of the pros and cons of adjudication
- A report on alternative forums for resolving conflicts outside of traditional adjudication. This report could include a discussion of the possibile forums, pros and cons of each, the legal and/or policy changes necessary to accommodate each forum and examples of where each has been successful.

Lessons from Analogous Cases

- Case studies of other states and countries that have gone through a similar groundwater management planning process
- Examples of different legal structures that have been used to achieve sustainable groundwater management.
- Case studies of other natural resource allocation decisions that may be analogous.
- Highlight success stories. Some potential examples:
  - Water district formation and management (Orange County)
  - Technical Advisory Committees (Stanislaus, Scott)
  - Voluntary GWMPs – where have they been successfully implemented
  - Adjudications

Economic Analysis

- Assessment of urban water users' willingness to pay for curtailing pumping (and under what circumstances)
- Cost assessment - What do different water users pay for groundwater in different basins across the state? In different sectors? How is it likely to change under the new law? (i.e., quantify economic impacts)
- Case studies and examples of water markets and other market-based solutions
  - Where are they currently being used in the California, other states, other countries?
  - What legal/policy changes are needed to allow for effective water markets?
  - What would the impact of tier-pricing be? Where is it being used? How would it apply to groundwater?
  - Economic analysis of different fee instruments in GSPs (i.e., pumping fees vs. infrastructure fees? tiered-pricing vs. pump tax?)
  - What is the relationship between GW production decrease and payment increase?

- Assessment of fundamental reorganization of state water system to maximize efficiency.
  - Working with UC Davis to rerun CALVIN model?
  - More desalination at coast and reversal of infrastructure to bring water inland

Variation across the State

- Assessment of the regional variations in GW management issues, plans and their practices
- Communication templates or assistance for different types of basins based on common issues
- Survey of what different users know about groundwater science and management

Technology and Models

- Develop models that can handle the intersection of land planning and groundwater
- Use technology to allow sharing and learning between stakeholders in a basin. Help them get at a common narrative and understanding of BMPs
- Catalog existing GW models or tools, including usability, audience, languages, details. Pros and cons of each. Which are best suited for various types of policies or management tasks?
- Develop economic models to integrate with existing flow models
- Create an information sharing platform for those doing groundwater management and implementing SGMA. Crowdsource information, including data, mapping, BMPs, governance.

Data collection/Sharing

- Suggestions and recommendations for best management practices for data collection, management and sharing between agencies
- An overview and guide to new and emerging technologies for data collection (e.g., geophysical methods) and their potential role in improved groundwater management decisions.

Research agenda

- Produce a research agenda that can be addressed by universities across the state

For more information visit:
waterinthewest.stanford.edu

Water in the West
Stanford University
Jerry Yang & Akiko Yamazaki Environment
& Energy Building
473 Via Ortega, MC 4205
Stanford, CA 94305
waterinthewest@stanford.edu

WATER IN THE WEST

Stanford Law School
Martin Daniel Gould Center for Conflict Resolution

Stanford Woods Institute for the Environment

Stanford University
The Bill Lane Center for the American West